REMARKS

This Preliminary Amendment cancels original claims 1 to 4, and adds new claims 5 to 12 in the underlying PCT Application No. PCT/DE03/01738. The new claims conform the claims to the U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.125, the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including the Title and Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. § 1.121 and § 1.125, a Marked Up Version Of The Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. In the Marked Up Version, underlining indicates added text and "strike-throughs" and double-brackets indicate deleted text. Approval and entry of the Substitute Specification (including Abstract) is respectfully requested.

The underlying PCT Application No. PCT/DE03/01738 includes an International Search Report, dated October 31, 2003, a copy of which is included. The Search Report includes a list of documents that were considered by the Examiner in the underlying PCT application.
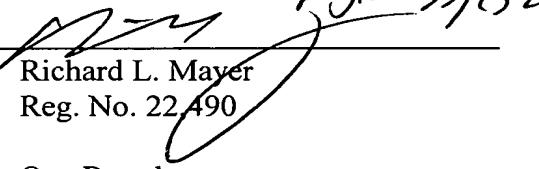
It is asserted that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,

KENYON & KENYON

Dated: 10/8/04

By: _____
Richard L. Mayer
Reg. No. 22,490

One Broadway
New York, New York 10004
Telephone: (212) 425-7200
Facsimile: (212) 425-5288

CUSTOMER NO. 26646

METHOD FOR CONTROLLING A FUEL METERING SYSTEM OF AN INTERNAL COMBUSTION ENGINE

~~Background Information~~

FIELD OF THE INVENTION

The present invention relates to a method for controlling a
fuel metering system of an internal combustion engine

5 ~~according to the definition of the species in Claim 1~~.

BACKGROUND INFORMATION

A method and device for controlling a fuel metering system of
an internal combustion engine is ~~described~~discussed, for

10 example, in German ~~P~~patent ~~Application DE~~document no. 199 45
618 ~~A1~~. In this ~~known~~ method, the activation duration of at
least one electrically operated valve determines the fuel
quantity to be injected. The minimum activation duration
during which fuel is only just injected is determined in

15 certain operating states. The activation duration is increased
or reduced, starting at an initial value. The activation
duration during which a signal undergoes a change is stored as
the minimum activation duration. The signal used is a quantity
characterizing the uniformity of rotation, an output signal of

20 a lambda sensor, or an output signal of an ion current sensor.
This method allows for an injection quantity drift over the
lifetime of the fuel injector in the range of the pilot
injection.

25 Non-prepublished German ~~P~~patent ~~D~~document ~~DE~~no. 102 15 610
~~describes~~discusses a system and method for correcting the
injection behavior of injectors, in which, in order to
increase the product output, an injector fuel-quantity
compensation is carried out at several test points, ~~preferably~~

30 ~~at~~which may be 4 test points, i.e., during the pilot

MARKED UP VERSION OF
SUBSTITUTE SPECIFICATION

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injection, during idle operation, at the emission point, and
during full-load operation.

This injector fuel-quantity compensation is necessary because
injectors of that kind have different fuel quantity maps due
to their mechanical manufacturing tolerances. A "fuel quantity
map" is understood to be the relationship between the
injection quantity, the rail pressure, and the activation time
(activation duration). As a consequence, in spite of the
electrically defined control, each individual injector fills
the combustion chamber with different fuel quantities.

In fact, to achieve as low a fuel consumption as possible
while complying with strict exhaust emission standards, the
injectors may only have very small tolerances in terms of the
injection quantity during operation. These small tolerances
required cannot be met due to the mechanical manufacturing
tolerances. In order to nevertheless guarantee a defined
injection quantity of the injectors, the injectors are
measured for their injection quantity at characteristic
operating points or test points after manufacture, and are
classified. The respective class must be known to the engine
control unit during the operation of the internal combustion
engine so that the control can be adapted to the particular
characteristics of the class specifically for each injector.
The class information is stored on the injector, for example,
by different codes such as a bar code, by resistors on the
injector, or by plaintext on the injector.

Moreover, electronic storage means, in which are stored, for
example, the class information, may be provided in the
injectors. These values may be read out from the injector by
the control unit via an interface and used in the subsequent
operation.

Over their lifetime, such common rail injectors are observed to have a fuel quantity drift, which is different for each individual injector and depends, for example, on the load profile or on the type of injector. This fuel quantity drift
5   has a negative effect in terms of low fuel consumption, on compliance with strict exhaust emission standards, and with respect to, for example, the noise level of the internal combustion engine. Until now, correction of the injection quantity drift over the lifetime of the injectors ~~is~~was only
10   ~~possible~~done in the pilot injection plateau using a method ~~described~~discussed in German ~~P~~patent ~~Application~~document no. 199 45 618 ~~A1~~. In contrast, fuel quantity drifts at other operating points can only be compensated for to a very limited degree, if at all.
15

~~Object of the Invention~~
SUMMARY OF THE INVENTION
It is therefore an object of the exemplary embodiment and/or exemplary method of the present invention to provide a method
20   which allows for fuel quantity correction, in particular, for correction of the fuel quantity drift over the lifetime of a piezoelectric common rail injector at operating points outside of the range of the pilot injection.

25   ~~Advantages of the Invention~~

In ~~a~~an exemplary method for controlling injectors of a fuel metering system of an internal combustion engine of the type mentioned at the outset, this objective is achieved by the
30   features of ~~Claim 1.~~

~~The basic idea~~the method described herein.

The exemplary embodiment and/or exemplary method of the

present invention ~~is to determine~~<u>includes determining</u>
correction values for the fuel quantity map of the injector
from the difference between the activation duration during
which a signal undergoes a change and the stored minimum
activation duration using transfer functions which define the
relationship between the minimum activation duration and the
activation duration at different test points of the injector,
respectively, and/or the relationship between the activation
durations at several test points of the injector. Thus, in a
way, the entire fuel quantity map of the injector is inferred
based on the range of the pilot injection, in which fuel
quantity drifts can be determined and corrected, using
transfer functions.

These transfer functions, in turn, ~~are preferably~~<u>may be</u>
determined during the injector fuel-quantity compensation at
the test points.

One ~~advantageous~~<u>exemplary</u> embodiment ~~proposes to store~~<u>includes</u>
<u>storing</u> the transfer functions on the injector, i.e., to
encode the injector with these transfer functions as well.

In accordance with another ~~advantageous~~<u>exemplary</u> embodiment,
the correction values are stored in an engine control unit.

~~Brief Description of the Drawing~~

~~Further advantages and features of the present invention will~~
~~be apparent from the following description and the graphical~~
~~representation of several exemplary embodiments.~~

~~In the drawing,~~
<u>BRIEF DESCRIPTION OF THE DRAWINGS</u>
Figure 1 shows a schematic representation of a portion of a

common rail system known from the prior art, in which the _exemplary _method according to the present invention is used~ ~and~.

5   Figure 2 schematically shows the injection quantity over the activation duration for different injection pressures to illustrate the _exemplary _method according to the present invention.

10   ~Description of the Exemplary Embodiments~
DETAILED DESCRIPTION
Figure 1 shows the high-pressure stage of a common rail accumulator injection system, of which only the main components and components that are essential for understanding
15   the present invention will be explained in more detail hereinafter.

The system includes a high-pressure pump 10 which is in communication with high-pressure accumulator ("rail") 14 via a
20   high-pressure delivery line 12. High-pressure accumulator 14 is connected to injectors 18 via further high-pressure delivery lines. In this representation, a high-pressure delivery line 16 and an injector 18 are shown. Injector 18 is mounted in an internal combustion engine of a motor vehicle.
25   The system shown is controlled by an engine control unit 20, which controls, in particular, injector 18.

Injector 18 is provided with a device 22 for storing information that relates to the individual injector 18. The
30   information stored in device 22 may be taken into account by engine control unit 20 so that each injector 18 may be controlled individually. The information ~preferably~may consists of correction values for the fuel quantity map of injector 18. Device 22 for storing the information may be

implemented, for example, as a data memory, or also as one or more electrical resistors, as a bar code, by alphanumeric coding, or the like, or also by a semiconductor integrated circuit located on injector 18. Engine control unit 20 may

5   also have a semiconductor integrated circuit for evaluating the information stored in device 22.

The injection quantity metered in by each injector 18 is defined as a function of the rail pressure in a characteristic

10   map stored in engine control unit 20, the characteristic map being determined based on several test points (pilot injection, idling, emission point, full load), which correspond to different operating states of the internal combustion engine. At each of these test points, fuel quantity

15   compensation is carried out in a manner which is known per se and ~~described~~DISCUSSED in German ~~P~~patent ~~d~~document ~~DE~~no. 102 15 610. The injection quantity is determined by the injection duration of injector 18; i.e., the time that passes between the start of injection and the end of injection.

20

In order to enable fuel quantity metering over the entire operating range of the internal combustion engine and injector 18, the compensation values are interpolated between the nodes defined by the test points.

25

Over the lifetime of injectors 18, a fuel quantity drift can be observed to the effect that the injection quantity, which was originally determined by defining the start of injection and the injection duration, changes over the life of injectors

30   18.

To compensate for this fuel quantity drift in a common rail injector, for example, in a common rail injector having a fully ballistic characteristic map without pilot injection

plateau (VE), which is schematically shown in Figure 2, an injector fuel-quantity compensation (IMA) is carried out, for example, at the five aforementioned test points LL (idling), VE1 (pilot injection 1), EM (emission point), VE2 (pilot

5　injection 2), and VL (full load). In addition, transfer functions Ü1 = f (VE1, LL), Ü2 = f (VE2, EM) and Ü3 = f (EM, VL) are determined.

In order to implement a fuel quantity correction over the

10　lifetime of injector 18, then the minimum activation duration during which fuel is only just injected is determined at two operating points VE1 and VE2; the activation duration being increased or reduced starting at an initial value, and the activation duration during which a signal undergoes a change

15　being stored as the minimum activation duration VE1' and VE2', respectively. Then, the differences Delta1 (VE1, VE1') and Delta2 (VE2, VE2') are determined, respectively. From these differences, correction values for the fuel quantity map of the injector are now determined and stored using the transfer

20　functions Ü1, Ü2, Ü3, which define the relationship between minimum injection duration VE1 and the injection duration during idle operation LL, the relationship between the second minimum injection duration and the injection duration at emission point EM, and the relationship between different

25　operating points, for example, the injection duration injection duration at emission point EM and the injection duration during full-load operation VL:

LL' = f (LL, Delta1, Ü1), EM' = f (EM, Delta2, Ü2) und VL' = f

30　(VL, EM', Ü3).

Thus, in a way, the injection durations at the further test points LL', EM', VL' of the fuel quantity map of injector 18 are inferred from the so-called "zero fuel quantity

correction", i.e., from the correction of the minimum
injection duration or minimum injection durations VE1, VE2
using transfer functions Ü1, Ü2, Ü3.

5   These transfer functions may be determined during the injector
       fuel-quantity compensation, or also independently of the
       injector fue-quantity compensation.

       Transfer functions Ü1, Ü2, Ü3 may either be stored on injector
10   18, i.e., injector 1~~5~~8 may be encoded with the transfer
       functions, or be stored in engine control unit 20 as a
       characteristic curve. Advantageously, map points LL' = f (LL,
       Delta1, Ü1), EM' = f (EM, Delta2, Ü2) and VL' = f (VL, EM',
       Ü3) are corrected each time a zero fuel quantity correction is
15   carried out. In this manner, a closed fuel quantity control
       loop is achieved.

AbstractABSTRACT OF THE DISCLOSURE

A method for controlling a fuel metering system of an internal
combustion engine, in which an. A activation duration of at
least one electrically operated injector determines the

5   injected fuel quantity to be injected; t. The minimum
activation duration during which fuel is only just injected
being determined in certain operating states, t. The
activation duration being increased or
reducedincreased/reduced starting at an initial value, and the

10   activation duration during which a signal undergoes a change
being stored as the minimum activation duration, is
characterized in thatn which the difference between the
activation duration during which a signal undergoes a change
and the stored minimum activation duration is determined, and

15   from this,which correction values for the fuel quantity map of
the injector are determined and stored using at least one
transfer function, which characterizes the relationship
between the minimum injection duration and activation
durations at several test points of the injector and/or the

20   relationship between the activation durations at different
test points of the injector.

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